Doctor of Philosophy in Aerospace Engineering

Degree Requirements		
Requirements	No. of Courses	No. of Credit Units
Compulsory Courses	1 (AE 795)	1
Required Elective Courses	5	15 (including 6 credits from Graduate MATH Courses)
PhD Thesis	1	25
Total	7	41

	Course Title	English Code/ No.	Arabic Code/ No.	Units			C.H.	Pre-requisites
				Th.	Pr.	Tr.		
1	Research Seminar in Aerospace Engineering	AE 795	هـ ط 795	1	1	0	1	Advisor's approval
2	Continuum Mechanics	AE 702	هـ ط 702	3	3	0	3	-
3	Advanced Dynamics	AE 704	هـ ط 704	3	3	0	3	MENG 262
4	Physical Gas Dynamics	AE 707	هـ ط 707	3	3	0	3	AE 412 ،AE413 ،AE 702
5	Experimental Methods	AE 709	هـ ط 709	2	2	0	3	-
6	Advanced Compressible Flow	AE 712	هـ ط 712	3	3	0	3	AE 412
7	Advanced Viscous Flow	AE 713	هـ ط 713	3	3	0	3	AE 412 ،AE 413
8	Hypersonic Flow	AE 714	هـ ط 714	3	3	0	3	AE 412 ،AE 413
9	Aerodynamic Configurations	AE 717	هـ ط 717	3	3	0	3	AE 712
10	Rotorcraft Aerodynamics	AE 718	هـ ط 718	3	3	0	3	AE 412
11	Cascade Aerodynamics	AE 719	هـ ط 719	3	3	0	3	AE 472
12	Computational Fluid Dynamics I	AE 721	هـ ط 721	3	3	0	3	-
13	Computational Fluid Dynamics II	AE 722	هـ ط 722	3	3	0	3	AE 721
14	Industrial CFD	AE 724	هـ ط 724	3	3	0	3	AE 721
15	Unstructured CFD Methods	AE 726	هـ ط 726	3	3	0	3	AE 722
16	High-Order CFD Methods	AE 728	هـ ط 728	3	3	0	3	AE 722
17	Turbulent Flow Modeling	AE 729	هـ ط 729	3	3	0	3	AE 713 ،AE 721
18	Computational Structural Analysis	AE 731	هـ ط 731	3	3	0	3	AE 432
19	Aerospace Structural Dynamics	AE 732	هـ ط 732	3	3	0	3	AE 432
20	Numerical Methods in Structural Dynamics	AE 733	هـ ط 733	2	2	2	3	AE 732
21	Theory of Elasticity	AE 734	هـ ط 734	3	3	0	3	AE 432
22	Aeroelasticity of Aircraft Structures	AE 735	هـ ط 735	3	3	0	3	AE 734
23	Rotorcraft Structural Dynamics and Aeroelasticity	AE 736	هـ ط 736	3	3	0	3	AE 734
24	Aircraft Structural Analysis and Design	AE 737	هـ ط 737	2	2	0	3	AE 433
25	Fracture Mechanics of Aerospace Structures	AE 738	هـ ط 738	3	3	0	3	AE 331
26	Mechanics and Design of Fiber-Reinforced Composite Structures	AE 739	هـ ط 739	3	3	0	3	AE 433
27	Aircraft Design I	AE 743	هـ ط 743	3	3	0	3	AE 361

28	Aircraft Design II	AE 745	هـ ط 745	2	2	0	3	AE 743
29	Aerospace Robust Control	AE 751	هـ ط 751	3	3	0	3	AE 463
30	Random Processes and Kalman Filtering	AE 753	هـ ط 753	3	3	0	3	AE 751
31	Aerospace Guidance and Navigation	AE 754	هـ ط 754	3	3	0	3	AE 753
32	Aerospace Vehicle Dynamics and Simulation	AE 755	هـ ط 755	3	3	0	3	AE 463
33	Nonlinear Systems and Control	AE 761	هـ ط 761	3	3	0	3	AE 751
34	Optimal Guidance and Control	AE 763	هـ ط 763	3	3	0	3	AE 463
35	Spacecraft Dynamics and Control	AE 765	هـ ط 765	3	3	0	3	AE 705, AE 761
36	Rotorcraft Stability and Control	AE 768	هـ ط 768	3	3	0	3	AE 463
37	Advanced Propulsion	AE 771	هـ ط 771	3	3	0	3	AE 472
38	Rocket Propulsion	AE 774	هـ ط 774	3	3	0	3	AE 472
39	Combustion Theory	AE 778	هـ ط 778	3	3	0	3	AE 472
40	Advanced Aircraft Reliability	AE 781	هـ ط 781	3	3	0	3	AE 481
41	Advanced Aircraft Maintenance Systems	AE 783	هـ ط 783	3	3	0	3	AE 481
42	Quality Management in Aerospace Industry	AE 785	هـ ط 785	3	3	0	3	-
43	**	MATH 6**	ر 6**	*	*	0	3	Advisor’s approval
44	**	MATH 6**	ر 6**	*	*	0	3	Advisor’s approval
45	Doctoral Thesis	AE 799	هـ ط 799	0	0	0	25	Advisor’s approval

توصيف المقررات

Course Code	Course Title	Credits	Prerequisite
AE 702	Continuum Mechanics	(3:3،0)	-

Notations and tensor calculus، stress and strain tensors، rate of deformation tensor، Eulerian and Lagrangian descriptions، conservation principles، constitutive formulations for elastic solids and viscous fluids، formulations of fluid mechanics and solid mechanics problems.

Course Code	Course Title	Credits	Prerequisite
AE 604	Advanced Dynamics	(3:3،0)	**MENG 262**
Kinematics of particles and rigid bodies، angular velocity، inertia properties، holonomic and nonholonomic constraints، generalized forces، equations of motion، Newtonian frames، linearization، energy and momentum integrals، collisions، mathematical representation of finite rotation.			

Course Code	Course Title	Credits	Prerequisite
AE 707	Physical Gas Dynamics	(3:3،0)	**AE 412، AE413، AE 702**
Principles of kinetic theory of gases، statistical mechanics as applied to gases، application to gases at high temperatures، very low pressures، etc.			

Course Code	Course Title	Credits	Prerequisite
AE 709	Experimental Methods	(3:2،2)	-
Procedure of experiment design and implementation، measurement methods، transducer fundamentals، instrumentation، optical systems، signal processing، noise theory، analog and digital electronic fundamentals، data acquisition and processing systems، experiments in solid، fluid mechanics and mechatronics، with emphasis on current research methods.			

Course Code	Course Title	Credits	Prerequisite
AE 712	Advanced Compressible Flow	(3:3،0)	**AE 412**
Classification of PDE’s governing subsonic، supersonic and transonic flows، full potential equation، transonic small disturbance theory، supersonic and transonic airfoil design، slender bodies of revolution flows، conical flows، wing flows.			

Course Code	Course Title	Credits	Prerequisite
AE 713	Advanced Viscous Flow	(3:3،0)	**AE 412، AE 413**
Review of governing equations، exact solutions of the Navier-Stokes equations، boundary layer theory، wakes and jets، Three-dimensional boundary layer، statistical theories of turbulence.			

Course Code	Course Title	Credits	Prerequisite
AE 714	Hypersonic Flow	(3:3،0)	**AE 412، AE 413**
High Mach number flows، Newtonian theory، small disturbance theory، thin shock layers، blunt body problems، hypersonic boundary layers and viscous interactions، thermally and calorically imperfect gases، statistical thermodynamics، kinetic theory of gases، equilibrium and non-equilibrium hypersonic flows، viscous high-temperature flows.			

Course Code	Course Title	Credits	Prerequisite
AE 717	Aerodynamic Configurations	(3:3‹0)	**AE 712**

Aerodynamic design; aircraft aerodynamics: configuration design options‹ delta wings‹ leading edge extensions‹ canard aircraft‹ tailless aircraft‹ aerodynamics of high lift devices‹high angle of attack aerodynamics; missile aerodynamics: subsonic and supersonic slender-body theory‹ wing-body interference‹ downwash‹ sidewash‹ wake vortices‹ wing-tail interference‹ drag prediction‹ aerodynamic controls‹ stability derivatives.

Course Code	Course Title	Credits	Prerequisite
AE 718	Rotorcraft Aerodynamics	(3:3‹0)	**AE 412**

Vortex wake modeling‹ analytical inflow theories‹ modern computational methods for rotary wing aerodynamic analysis‹ aerodynamic noise.

Course Code	Course Title	Credits	Prerequisite
AE 719	Cascade Aerodynamics	(3:3‹0)	**AE 472**

Cascade model‹ cascade testing‹ incompressible and compressible flow theories‹ viscous flow‹ numerical predictions techniques‹ design application of cascade data.

Course Code	Course Title	Credits	Prerequisite
AE 721	Computational Fluid Dynamics I	(3:3‹0)	-

Introduction to computational fluid dynamics‹ classification of PDE's‹ finite difference method‹ finite volume method‹ finite element method‹ basic concepts of discretization: spatial and temporal discretization‹ stability analysis‹ convergence‹ consistency and efficiency‹ explicit‹ implicit‹ and iterative techniques; solutions of model equations of hyperbolic‹ parabolic and elliptic types.

Course Code	Course Title	Credits	Prerequisite
AE 722	Computational Fluid Dynamics II	(3:3‹0)	**AE 721**

Advanced numerical methods for solving Navier-Stokes and Euler equations: pressure-based techniques‹ flux vector splitting‹ flux difference splitting‹ flux limited‹ initial and boundary conditions‹ curvilinear coordinate systems‹ grid generation.

Course Code	Course Title	Credits	Prerequisite
AE 724	Industrial CFD	(3:3‹0)	**AE 721**

Geometry modeling‹ grid generation‹ solution strategy‹ post-processing‹ parametric studies; industrial applications involving: turbulence‹ multiphase flow‹ heat transfer‹ and combustion.

Course Code	Course Title	Credits	Prerequisite
AE 726	Unstructured CFD Methods	(3:3‹0)	**AE 722**

Unstructured Grids‹ data structures and algorithms‹ spatial discretisation: cell-centered schemes‹ median-dual cell-vertex schemes‹ temporal discretisation: explicit multistep schemes‹ implicit schemes‹ boundary conditions‹ convergence acceleration techniques.

Course Code	Course Title	Credits	Prerequisite
AE 728	High-Order CFD Methods	(3:3‹0)	**AE 722**

High-order finite difference methods: central explicit‹ central compact‹ upwind WENO‹spectral methods‹ spectral volume methods‹ discontinuous Galerkin method.

Course Code	Course Title	Credits	Prerequisite
AE 729	Turbulent Flow Modeling	(3:3‹0)	**AE 713 , AE 721**

Levels of turbulence modeling‹ Reynolds Averaged Navier Stokes (RANS) approach :algebraic models‹ first order closure‹ second order closure‹ Large Eddy Simulation (LES) approach‹ Detached Eddy Simulation (DES) approach‹ Direct Numerical Simulation (DNS) approach.

Course Code	Course Title	Credits	Prerequisite
AE 731	Computational Structural Analysis	(3:3‹0)	**AE 432**

Finite element methods for linear static structural analysis‹ basic tools of the finite element method for spring systems‹ rods‹ truss‹ and frames‹ formulation and solutions of various structural elements.

Course Code	Course Title	Credits	Prerequisite
AE 732	Aerospace Structural Dynamics	(3:3‹0)	**AE 432**

Dynamic response of single-degree-of-freedom systems‹ Lagrange's equations‹ modal decoupling‹ multi-degrees-of-freedom systems‹ vibration of beams‹ membranes and plates‹ modal analysis of aerospace structures‹ system identification methods‹ experimental methods.

Course Code	Course Title	Credits	Prerequisite
AE 733	Numerical Methods in Structural Dynamics	(3:2‹2)	**AE 732**

Rayleigh quotient‹ Rayleigh-Ritz and Galerkin methods‹ extraction of eigenvalues and eigenvectors‹ analysis of forced harmonic response‹ direct time integration of large-scale systems‹ nonlinear vibration methods.

Course Code	Course Title	Credits	Prerequisite
AE 734	Theory of Elasticity	(3:3‹0)	**AE 432**
Governing equations of linear elasticity‹ plane elasticity‹ boundary value problems‹ airy stress function and complex variable methods‹ simple three-dimensional solutions‹ stresses and deformations in continuum media‹ equilibrium equations and energy principles‹ linear and nonlinear elasticity of beams‹ plates and shells.			

Course Code	Course Title	Credits	Prerequisite
AE 735	Aeroelasticity of Aircraft Structures	(3:3‹0)	**AE 734**
Analysis of aeroelastic phenomena in fixed-wing aircraft‹ static aeroelasticity‹ dynamic aeroelasticity‹ dynamic response and transient stresses in aircraft structures.			

Course Code	Course Title	Credits	Prerequisite
AE 736	Rotorcraft Structural Dynamics and Aeroelasticity	(3:3‹0)	**AE 734**
Elementary blade dynamics‹ flap-lag dynamics‹ ground resonance‹ structural dynamics of rotating beams‹ linear and nonlinear elastic blade analysis‹ harmonic balance and trim‹ Floquet theory.			

Course Code	Course Title	Credits	Prerequisite
AE 737	Aircraft Structural Analysis and Design	(3:2‹2)	**AE 433**
Stress and strength analysis of wing‹ fuselage‹ empennage‹ fin‹ and landing gear. Structural analysis of ribs‹ frames‹ stiffeners‹ webs‹ and skins‹ diagonal semi-tension field beam. Design‹ building and testing exercise of a principle component of a small aircraft.			

Course Code	Course Title	Credits	Prerequisite
AE 738	Fracture Mechanics of Aerospace Structures	(3:3‹0)	**AE 331**
Fatigue load spectra‹ structural safety‹ reliability and life prediction‹ crack initiation and growth‹ crack arrest and closure‹ inspection of structures by non-destructive testing‹ repairs of structures.			

Course Code	Course Title	Credits	Prerequisite
AE 739	Mechanics and Design of Fiber-Reinforced Composite Structures	(3:3‹0)	**AE 433**
Composite material systems‹ anisotropic plate and shell theory‹ shear deformation‹ hydrothermal and interlaminar stresses‹ finite element modeling‹ damage‹ failure‹ durability of composite materials‹ design case studies including thin-walled composite structures.			

Course Code	Course Title	Credits	Prerequisite
AE 744	Aircraft Design I	(3:2‹2)	**AE 361**
Characteristics of aerospace vehicles‹ disciplines within aerospace vehicle design‹ design features‹ initial sizing‹ preliminary configuration design‹ design optimization‹ performance analysis.			

Course Code	Course Title	Credits	Prerequisite
AE 745	Aircraft Design II	(3:2‹ 2)	**AE 744**
Layout design of wing‹ fuselage and empennage. Aircraft cost estimation: design‹ development‹ manufacturing and operation.			

Course Code	Course Title	Credits	Prerequisite
AE 751	Aerospace Robust Control	(3:3‹0)	**AE 463**
State space representation of linear systems‹ stability‹ controllability and observability‹ linear feedback control‹ observers‹ introduction to Kalman filtering‹ robustness issues in controller analysis and design‹ LQ analysis‹ H2 norm‹ LQR‹ LQG‹ uncertainty modeling‹ small gain theorem‹ H-infinity performance‹ mixed-norm H2/H-infinity problem.			

Course Code	Course Title	Credits	Prerequisite
AE 753	Random Processes and Kalman Filtering	(3:3‹0)	**AE 751**
Probability and random variables and processes‹ correlation‹ shaping filters‹ simulation of sensor errors‹ Wiener filter‹ random vectors‹ covariance propagation‹ recursive least squares‹ linear Kalman filter‹ extended Kalman filter.			

Course Code	Course Title	Credits	Prerequisite
AE 754	Aerospace Guidance and Navigation	(3:3‹0)	**AE 753**
Earth’s shape and gravity‹ inertial navigation‹ GPS aiding‹ error analysis‹ guidance systems‹ analysis of the guidance loop‹ estimation of guidance variables‹ adjoint analysis‹ radar detection‹ waveforms‹ ambiguity function‹ radar operation and design‹ Satellite modeling‹ identification‹ and real-time control‹ rules & regulations of satellite telecommunications.			

Course Code	Course Title	Credits	Prerequisite
AE 755	Aerospace Vehicle Dynamics and Simulation	(3:3‹0)	**AE 463**
Reference frames and transformations‹ general equations of unsteady motion‹ perturbation equations‹ application to fixed-wing‹ rotary-wing‹ missiles and space vehicles‹ stability characteristics‹ flight in turbulent atmosphere‹ models for subsystems of propulsion‹ autopilot‹ actuator‹ navigation‹ guidance and seeker.			

Course Code	Course Title	Credits	Prerequisite
AE 761	Nonlinear Systems and Control	(3:3‹0)	**AE 751**
Classical analysis techniques for nonlinear systems‹ Lyapanov stability‹ absolute stability‹ dissipativity‹ control Lyapanov functions‹ feedback linearization‹ backstepping control‹ adaptive control.			

Course Code	Course Title	Credits	Prerequisite
AE 763	Optimal Guidance and Control	(3:3‹0)	**AE 463**
Constrained optimization‹ Euler-Lagrange formulation‹ Pontryagin's minimum principle‹ systems with quadratic performance index‹ Hamilton-Jacobi-Bellman approach‹ second variation and neighboring extremals‹ singular solutions‹ numerical solution techniques.			

Course Code	Course Title	Credits	Prerequisite
AE 765	Spacecraft Dynamics and Control	(3:3‹0)	**AE 705‹ AE761**
Review of particle dynamics‹ Newton's laws‹ the two body problem‹ Kepler's equation‹ rigid body dynamics‹ Euler's equations‹ Spacecraft attitude dynamics and determination‹ Gyroscopic instruments‹ attitude control‹ underactuated spacecraft dynamics and control.			

Course Code	Course Title	Credits	Prerequisite
AE 768	Rotorcraft Stability and Control	(3:3‹0)	**AE 463**
Rotorcraft general equations of motion‹ rotor forces and moments‹ helicopter stability and control characteristics‹ handling qualities‹ flight control system design.			

Course Code	**Course Title**	**Credits**	**Prerequisite**
AE 771	Advanced Propulsion	(3:3‹0)	**AE 472**
Airbreathing propulsion systems‹ airbreathing engines performance analysis‹ compression‹ combustion and expansion system components‹ special hypersonic airbreathing propulsion topics.			

Course Code	Course Title	Credits	Prerequisite
AE 774	Rocket Propulsion	(3:3‹0)	**AE 472**
Definitions and classifications‹ nozzle theory‹ liquid propellant rocket fundamentals‹ solid propellant rocket fundamentals‹ advanced propulsion systems‹ rocket testing.			

Course Code	Course Title	Credits	Prerequisite
AE 778	Combustion Theory	(3:3‹0)	**AE 472**
Fuels‹ thermochemistry of combustion‹ chemical kinetics and equilibrium‹ laminar premixed combustion‹ turbulent premixed and diffusion combustion‹ combustion modeling‹ numerical predictions methods.			

Course Code	Course Title	Credits	Prerequisite
AE 781	Advanced Aircraft Reliability	(3:3‹0)	**AE 481**
Reliability testing‹ censoring‹ MTTF estimates‹ confidence intervals‹ Bayesian analysis‹ renewal theory‹ Monte Carlo simulation‹ loads and capacity‹ safety factors‹ extreme value distributions‹ repetitive loading‹ time dependent failure raters‹ failure interactions‹ Markov analysis.			

Course Code	Course Title	Credits	Prerequisite
AE 783	Advanced Aircraft Maintenance Systems	(3:3‹0)	**AE 481**
Reliability centered maintenance (RCM)‹ failure detection‹ maintenance tasks‹ developing initial maintenance program‹ evolution of RCM program‹ RCM analysis of A/C systems‹ power plant and structures‹ the use of operating information‹ auditing of RCM program.			

Course Code	Course Title	Credits	Prerequisite
AE 785	Quality Management in Aerospace Industry	(3:3‹0)	-
Total quality management‹ Deming approach‹ design for quality‹ reliability‹ production for quality‹ quality planning‹ quality control‹ quality assurance‹ Kaizen approach to quality improvement.			